

Novel tricyclic spiroderivatives as modulators of chemokine receptor activity.

The present invention relates to novel compounds, processes for their preparation, pharmaceutical compositions containing them and their use in therapy.

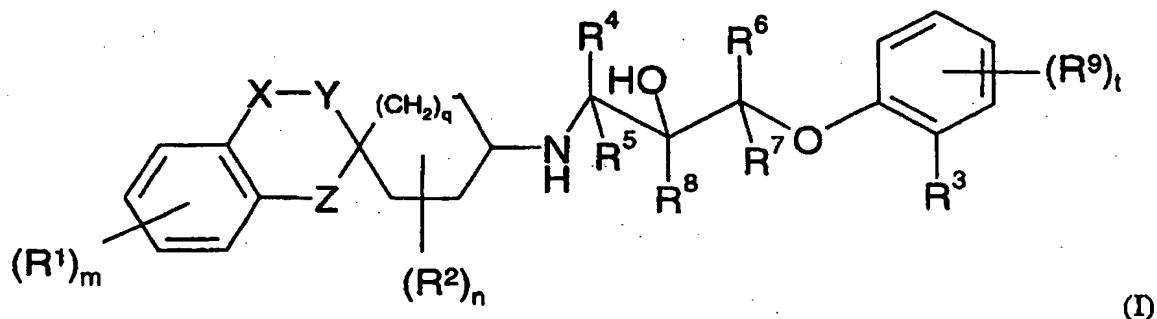
Chemokines play an important role in immune and inflammatory responses in various diseases and disorders, including asthma and allergic diseases, as well as autoimmune pathologies such as rheumatoid arthritis and atherosclerosis. These small secreted molecules are a growing superfamily of 8-14 kDa proteins characterised by a conserved four cysteine motif. The chemokine superfamily can be divided into two main groups exhibiting characteristic structural motifs, the Cys-X-Cys (C-X-C) and Cys-Cys (C-C) families. These are distinguished on the basis of a single amino acid insertion between the NH-proximal pair of cysteine residues and sequence similarity.

The C-X-C chemokines include several potent chemoattractants and activators of neutrophils such as interleukin-8 (IL-8) and neutrophil-activating peptide 2 (NAP-2).

The C-C chemokines include potent chemoattractants of monocytes and lymphocytes but not neutrophils such as human monocyte chemotactic proteins 1-3 (MCP-1, MCP-2 and MCP-3), RANTES (Regulated on Activation, Normal T Expressed and Secreted), eotaxin and the macrophage inflammatory proteins 1 α and 1 β (MIP-1 α and MIP-1 β).

Studies have demonstrated that the actions of the chemokines are mediated by subfamilies of G protein-coupled receptors, among which are the receptors designated CCR1, CCR2, CCR2A, CCR2B, CCR3, CCR4, CCR5, CCR6, CCR7, CCR8, CCR9, CCR10, CXCR1, CXCR2, CXCR3 and CXCR4. These receptors represent good targets for drug development since agents which modulate these receptors would be useful in the treatment of disorders and diseases such as those mentioned above.

In accordance with the present invention, there is therefore provided a compound of formula



wherein

m is 0, 1, 2, 3 or 4;

each R¹ independently represents halogen, cyano, hydroxyl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ alkoxy or sulphonamido (-SO₂NH₂); either X represents a bond, -CH₂-, -O- or -C(O)- and Y represents a bond, -CH₂-, -O- or -C(O)-, or X and Y together represent a group -CH=C(CH₃)- or -C(CH₃)=CH-, and Z represents a bond, -O-, -NH- or -CH₂-, provided that only one of X, Y and Z can represent a bond at any one time and provided that X and Y do not both simultaneously represent -O- or -C(O)-;

n is 0, 1 or 2;

each R² independently represents halogen or C₁-C₆ alkyl;

q is 0 or 1;

R³ represents -NHC(O)R¹⁰, -C(O)NR¹¹R¹² or -COOR^{12a};

R⁴, R⁵, R⁶, R⁷ and R⁸ each independently represent a hydrogen atom or a C₁-C₆ alkyl group;

t is 0, 1 or 2;

each R⁹ independently represents halogen, cyano, hydroxyl, carboxyl,

C₁-C₆ alkoxy, C₁-C₆ alkoxy carbonyl, C₁-C₆ haloalkyl, or C₁-C₆ alkyl optionally substituted by at least one substituent selected from carboxyl and C₁-C₆ alkoxy carbonyl;

R¹⁰ represents a group C₁-C₆ alkyl, C₂-C₆ alkenyl, C₃-C₆ cycloalkyl, adamantyl, C₅-C₆ cycloalkenyl, phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom selected from nitrogen, oxygen and

sulphur, each of which may be optionally substituted by one or more substituents independently selected from nitro, hydroxyl, oxo, halogen, carboxyl, C₁-C₆ alkyl, C₁-C₆ alkoxy, C₁-C₆ alkylthio, C₁-C₆ alkylcarbonyl, C₁-C₆ alkoxy carbonyl, phenyl and -NHC(O)-R¹³, or

5 R¹⁰ represents a group -NR¹⁴R¹⁵ or -O-R¹⁶;

R¹¹ and R¹² each independently represent (i) a hydrogen atom, (ii) a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring heteroatom selected from nitrogen, oxygen and sulphur and optionally further comprising a bridging group, the ring being optionally substituted with at least one substituent selected from 10 halogen, hydroxyl, C₁-C₆ alkyl, C₁-C₆ hydroxyalkyl and C₁-C₆ haloalkyl, (iii) a C₁-C₆ alkyl group optionally substituted by at least one substituent selected from halogen, amino (-NH₂), hydroxyl, C₁-C₆ haloalkyl, carboxyl, C₁-C₆ alkoxy, C₁-C₆ alkoxy carbonyl, C₁-C₆ alkylcarbonylamino and a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring heteroatom selected from nitrogen, 15 oxygen and sulphur and optionally further comprising a bridging group, the ring being optionally substituted with at least one substituent selected from halogen, hydroxyl, oxo (=O), C₁-C₆ alkyl, C₁-C₆ hydroxyalkyl and C₁-C₆ haloalkyl, or (iv) C₁-C₆ alkylsulphonyl, or

10 R¹¹ and R¹² together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen, oxygen or sulphur atom and that is optionally fused to a benzene ring to form a 8- to 11-membered ring system, the heterocyclic ring or ring system being optionally substituted with at least one substituent selected from halogen, hydroxyl, amido (-CONH₂), C₁-C₆ alkyl, C₁-C₆ hydroxyalkyl, C₁-C₆ alkoxy, C₁-C₆ alkoxy carbonyl, 15 C₁-C₆ haloalkyl, C₁-C₆ alkylamino, di-C₁-C₆ alkylamino, C₁-C₆ alkylcarbonyl, C₁-C₆ alkylcarbonylamino, C₁-C₆ alkylaminocarbonyl, di-C₁-C₆ alkylaminocarbonyl, phenyl, halophenyl, phenylcarbonyl, phenylcarbonyloxy and hydroxydiphenylmethyl;

12a R^{12a} represents a hydrogen atom or a C₁-C₆ alkyl group;

13 R¹³ represents a C₁-C₆ alkyl, amino (-NH₂) or phenyl group;

R¹⁴ and R¹⁵ each independently represent a hydrogen atom, or a group C₁-C₆ alkyl, C₁-C₆ alkylsulphonyl, phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom selected from nitrogen, oxygen and sulphur, each group being optionally substituted as defined above for R¹⁰, or

R¹⁴ and R¹⁵ together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen, oxygen or sulphur atom, the heterocyclic ring being optionally substituted by at least one hydroxyl; and

R¹⁶ represents a hydrogen atom, or a group C₁-C₆ alkyl, phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom selected from nitrogen, oxygen and sulphur, each group being optionally substituted as defined above for R¹⁰;

or a pharmaceutically acceptable salt or solvate thereof.

In the context of the present specification, unless otherwise stated, an alkyl or alkenyl substituent group or an alkyl moiety in a substituent group may be linear or branched. The alkyl moieties in a di-alkylamino or di-alkylaminocarbonyl substituent group may be the same or different. A haloalkyl or halophenyl substituent group will comprise at least one halogen atom, e.g. one, two, three or four halogen atoms. A hydroxyalkyl substituent may contain one or more hydroxyl groups but preferably contains one or two hydroxyl groups. In the ring substituted by R², R² may be attached to any suitable ring carbon atom including the carbon atom of (CH₂)_q. When R¹¹ and R¹² or R¹⁴ and R¹⁵ represent a 4- to 7-membered saturated heterocycle, it should be understood that the heterocycle will contain no more than two ring heteroatoms: the nitrogen ring atom to which R¹¹ and R¹² or R¹⁴ and R¹⁵ are attached and optionally a nitrogen, oxygen or sulphur ring atom. In the definition of R¹⁰ (or R¹⁴, R¹⁵ or R¹⁶) it should be noted that the saturated or unsaturated 5- to 10-membered heterocyclic ring system may have alicyclic or aromatic properties. Similarly, in the definition of R¹¹ or R¹², a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring heteroatom may have alicyclic or aromatic properties. An unsaturated ring system will be partially or fully unsaturated.

In an embodiment of the invention, m is 0 or 1.

Each R¹ independently represents halogen (e.g. chlorine, fluorine, bromine or iodine), cyano, hydroxyl, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy) or sulphonamido.

10 In an embodiment of the invention, each R¹ independently represents halogen, C₁-C₆, preferably C₁-C₄, alkyl or C₁-C₆, preferably C₁-C₄, haloalkyl.

In another embodiment, each R¹ independently represents fluorine, chlorine, methyl or trifluoromethyl, particularly chlorine.

15

Combinations of X and Y of particular interest include any one or more of the following:

X	Y
bond	O
O	bond
CH ₂	bond
bond	CH ₂
CH ₂	O
O	CH ₂
C(O)	O
O	C(O)
CH ₂	CH ₂
-CH=C(CH ₃)-	

In an embodiment of the invention, X and Y have the meanings shown below:

X	Y
bond	O
O	bond
CH ₂	O
O	CH ₂
C(O)	O
O	C(O)
CH ₂	CH ₂
-CH=C(CH₃)-	

In a further embodiment, X and Y have the meanings shown below:

X	Y
bond	O
O	bond
CH ₂	bond
bond	CH ₂

In an embodiment of the invention, Z represents a bond, -O- or -CH₂-.

Combinations of X, Y and Z of particular interest include any one or more of the
10 following:

X	Y	Z
bond	O	CH ₂
O	bond	CH ₂
CH ₂	bond	O
bond	CH ₂	O
CH ₂	O	bond
C(O)	O	bond
O	C(O)	bond
CH ₂	CH ₂	bond
O	bond	O
bond	O	O
CH ₂	CH ₂	O
O	CH ₂	CH ₂
-CH=C(CH₃)-		bond

In an embodiment of the invention, X, Y and Z have the meanings shown below:

X	Y	Z
bond	O	CH ₂
O	bond	CH ₂
CH ₂	O	bond
O	CH ₂	bond
C(O)	O	bond
O	C(O)	bond
CH ₂	CH ₂	bond
bond	O	O
O	bond	O
-CH=C(CH₃)-		bond

In another embodiment of the invention, X, Y and Z have the meanings shown below:

X	Y	Z
bond	O	CH ₂
O	bond	CH ₂
CH ₂	bond	O
bond	CH ₂	O

Each R² independently represents halogen (e.g. chlorine, fluorine, bromine or iodine) or

5 C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl).

In an embodiment of the invention, n is 1 and R² represents halogen, particularly fluorine.

10 In an embodiment of the invention, R³ represents -NHC(O)R¹⁰.

In another embodiment of the invention, R³ represents -C(O)NR¹¹R¹².

15 R⁴, R⁵, R⁶, R⁷ and R⁸ each independently represent a hydrogen atom or a C₁-C₆, preferably C₁-C₄, alkyl group (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl).

In an embodiment of the invention, R⁴, R⁵, R⁶, R⁷ and R⁸ each independently represent a hydrogen atom or a methyl group.

20 In another embodiment of the invention, R⁴, R⁵, R⁶ and R⁷ each represent a hydrogen atom and R⁸ represents a methyl group.

In an embodiment of the invention, R⁴, R⁵, R⁶, R⁷ and R⁸ each represent a hydrogen atom.

In an embodiment of the invention, t is 0, 1 or 2, particularly 0 or 1.

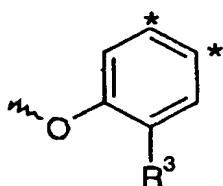
Each R⁹ independently represents halogen (e.g. chlorine, fluorine, bromine or iodine),
 5 cyano, hydroxyl, carboxyl, C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-
 propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl,
 ethoxycarbonyl, n-propoxycarbonyl or n-butoxycarbonyl), C₁-C₆, preferably
 10 C₁-C₄, haloalkyl (e.g. trifluoromethyl), or C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl,
 ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl) optionally
 substituted by at least one substituent (e.g. one, two or three substituents) independently
 selected from carboxyl and C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g.
 methoxycarbonyl, ethoxycarbonyl, n-propoxycarbonyl or n-butoxycarbonyl).

In an embodiment of the invention, each R⁹ independently represents halogen, cyano,
 15 hydroxyl, carboxyl, C₁-C₆, preferably C₁-C₄, alkoxy, C₁-C₆, preferably C₁-C₄,
 alkoxy carbonyl, C₁-C₆, preferably C₁-C₄, haloalkyl or C₁-C₆, preferably C₁-C₄, alkyl.

In another embodiment of the invention, each R⁹ independently represents halogen,
 hydroxyl, carboxyl, methyl, methoxy, methoxycarbonyl or trifluoromethyl.

20 In a further embodiment, each R⁹ independently represents halogen (particularly fluorine)
 or hydroxyl.

R⁹ is preferably bound to a carbon atom located in the *para* position with respect to the
 25 carbon atom to which either the oxygen atom or the group R³ is bound, as indicated by the
 asterisks in the partial structure shown below:



R¹⁰ may represent a group C₁-C₆, preferably C₁-C₄, alkyl group (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₂-C₆, preferably C₂-C₄, alkenyl, C₃-C₆ cycloalkyl (cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl), adamantyl, C₅-C₆ cycloalkenyl, phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur, each of which (i.e. each of the recited groups and the ring system) may be optionally substituted by one or more (e.g. one, two, three or four) substituents independently selected from nitro, hydroxyl, oxo, halogen (e.g. fluorine, chlorine, bromine or iodine), carboxyl, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkylthio (e.g. methylthio or ethylthio), C₁-C₆, preferably C₁-C₄, alkylcarbonyl (e.g. methylcarbonyl, ethylcarbonyl, n-propylcarbonyl, isopropylcarbonyl, n-butylicarbonyl, n-pentylcarbonyl or n-hexylcarbonyl), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), phenyl and -NHC(O)-R¹³.

The saturated or unsaturated 5- to 10-membered heterocyclic ring system in R¹⁰ may be monocyclic or polycyclic (e.g. bicyclic), examples of which include pyrrolidinyl, piperidinyl, pyrazolyl, thiazolidinyl, thienyl, isoxazolyl, thiadiazolyl, pyrrolyl, furanyl, thiazolyl, indolyl, quinolinyl, benzimidazolyl, triazolyl, tetrazolyl, pyridinyl and combinations of any two or more thereof.

In an embodiment of the invention, R¹⁰ represents a group C₁-C₆ alkyl, C₃-C₆ cycloalkyl, phenyl or a saturated or unsaturated 5- to 6-membered heterocyclic ring system comprising at least one ring heteroatom (e.g. one or two ring heteroatoms independently) selected from nitrogen, oxygen and sulphur, each of which (i.e. each of the recited groups and the ring system) may be optionally substituted by one, two, three or four substituents independently selected from nitro, hydroxyl, oxo, halogen, carboxyl, C₁-C₆, preferably C₁-C₄, alkyl, C₁-C₆, preferably C₁-C₄, alkoxy, C₁-C₆, preferably C₁-C₄, alkylthio,

C₁-C₆, preferably C₁-C₄, alkylcarbonyl, C₁-C₆, preferably C₁-C₄, alkoxy carbonyl, phenyl and -NHC(O)-R¹³.

In another embodiment of the invention, R¹⁰ represents a group C₁-C₆ alkyl, C₃-C₆ cycloalkyl or phenyl, each of which may be optionally substituted by one or two substituents independently selected from halogen, C₁-C₆, preferably C₁-C₄, alkyl and C₁-C₆, preferably C₁-C₄, alkoxy.

In still another embodiment of the invention, R¹⁰ represents C₁-C₆ alkyl, cyclopentyl or phenyl, particularly C₁-C₆ alkyl.

Alternatively, R¹⁰ may represent a group -NR¹⁴R¹⁵ or -O-R¹⁶.

R¹⁴ and R¹⁵ each independently represent a hydrogen atom, or a group C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, alkylsulphonyl (e.g. methylsulphonyl, ethylsulphonyl, n-propylsulphonyl, isopropylsulphonyl, n-butylsulphonyl, isobutylsulphonyl, tert-butylsulphonyl, n-pentylsulphonyl or n-hexylsulphonyl), phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur, each group (i.e. each of the recited groups including the ring system) being optionally substituted as defined above for R¹⁰ (that is, optionally substituted with one or more (e.g. one, two, three or four) substituents independently selected from nitro, hydroxyl, oxo, halogen (e.g. fluorine, chlorine, bromine or iodine), carboxyl, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkylthio (e.g. methylthio or ethylthio), C₁-C₆, preferably C₁-C₄, alkylcarbonyl (e.g. methylcarbonyl, ethylcarbonyl, n-propylcarbonyl, isopropylcarbonyl, n-butylcarbonyl, n-pentylcarbonyl or

n-hexylcarbonyl), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), phenyl and -NHC(O)-R¹³).

or R¹⁴ and R¹⁵ together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen,

5 oxygen or sulphur atom (e.g. pyrrolidinyl, piperidinyl, morpholino, piperazinyl or thiomorpholiny), the heterocyclic ring being optionally substituted by at least one hydroxyl (e.g. one or two hydroxyls).

In R¹⁴ or R¹⁵, the saturated or unsaturated 5- to 10-membered heterocyclic ring system

10 may be monocyclic or polycyclic (e.g. bicyclic), examples of which include pyrrolidinyl, piperidinyl, pyrazolyl, thiazolidinyl, thienyl, isoxazolyl, thiadiazolyl, pyrrolyl, furanyl, thiazolyl, indolyl, quinolinyl, benzimidazolyl, triazolyl, tetrazolyl, pyridinyl and combinations of any two or more thereof.

15 In an embodiment of the invention, R¹⁴ and R¹⁵ each independently represent a hydrogen atom or a C₁-C₆ alkyl or C₁-C₆ alkylsulphonyl group, each group being optionally substituted as defined above for R¹⁰, or R¹⁴ and R¹⁵ together with the nitrogen atom to which they are attached form a 5- to 6-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen, oxygen or sulphur atom, the heterocyclic ring being optionally substituted by at least one hydroxyl.

In a further embodiment, R¹⁴ and R¹⁵ each independently represent a hydrogen atom or a C₁-C₆ alkylsulphonyl group, or R¹⁴ and R¹⁵ together with the nitrogen atom to which they are attached form a 5- to 6-membered saturated heterocyclic ring that is optionally substituted by at least one hydroxyl.

In a still further embodiment, R¹⁴ and R¹⁵ each independently represent a hydrogen atom or a methylsulphonyl group, or R¹⁴ and R¹⁵ together with the nitrogen atom to which they are attached form a pyrrolidinyl or piperidinyl ring optionally substituted by one hydroxyl group.

R¹⁶ represents a hydrogen atom, or a group C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), phenyl or a saturated or unsaturated 5- to 10-membered heterocyclic ring system comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur, each group (i.e. each of the recited groups including the ring system) being optionally substituted as defined above for R¹⁰ (that is, optionally substituted with one or more (e.g. one, two, three or four) substituents independently selected from nitro, hydroxyl, oxo, halogen (e.g. fluorine, chlorine, bromine or iodine), carboxyl, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkylthio (e.g. methylthio or ethylthio), C₁-C₆, preferably C₁-C₄, alkylcarbonyl (e.g. methylcarbonyl, ethylcarbonyl, n-propylcarbonyl, isopropylcarbonyl, n-butylcarbonyl, n-pentylcarbonyl or n-hexylcarbonyl), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), phenyl and -NHC(O)-R¹³).

In R¹⁶, the saturated or unsaturated 5- to 10-membered heterocyclic ring system may be monocyclic or polycyclic (e.g. bicyclic), examples of which include pyrrolidinyl, piperidinyl, pyrazolyl, thiazolidinyl, thienyl, isoxazolyl, thiadiazolyl, pyrrolyl, furanyl, thiazolyl, indolyl, quinolinyl, benzimidazolyl, triazolyl, tetrazolyl, pyridinyl and combinations of any two or more thereof.

R¹¹ and R¹² each independently represent

(i) a hydrogen atom,

(ii) a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur and optionally further comprising a bridging group (examples of which include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, bicyclo[2.2.1]heptyl, phenyl, pyrolyl, imidazolyl, pyridinyl, pyrazinyl, pyridazinyl,

tetrazolyl, pyrimidinyl, thienyl, furanyl, tetrahydrofuranyl and combinations of any two or more thereof), the ring being optionally substituted with at least one substituent (e.g. one, two or three substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), hydroxyl, C₁-C₆, preferably C₁-C₅, alkyl (e.g. methyl, ethyl,

5 n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, 1,1-dimethylpropyl or n-hexyl), C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃) and C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl),

10 (iii) a C₁-C₆ alkyl group optionally substituted by at least one substituent (e.g. one, two, three or four substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), amino (-NH₂), hydroxyl, C₁-C₆, preferably C₁-C₄, haloalkyl (e.g.

15 trifluoromethyl), carboxyl, C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkoxycarbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), C₁-C₆, preferably C₁-C₄, alkylcarbonylamino (e.g.

20 methylcarbonylamino or ethylcarbonylamino) and a 3- to 6-membered saturated or

15 unsaturated ring optionally comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur and optionally further comprising a bridging group (examples of which include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, bicyclo[2.2.1]heptyl, phenyl, pyrrolyl, imidazolyl, pyridinyl, pyrazinyl, pyridazinyl, tetrazolyl, pyrimidinyl, thienyl, furanyl,

20 tetrahydrofuran and combinations of any two or more thereof), the ring being optionally substituted with at least one substituent (e.g. one, two or three substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), hydroxyl, oxo (=O), C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH,

25 -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃) and C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl), or

(iv) C₁-C₆, preferably C₁-C₄, alkylsulphonyl (e.g. methylsulphonyl or ethylsulphonyl),

or

30 R¹¹ and R¹² together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen,

oxygen or sulphur atom (e.g. pyrrolidinyl, piperidinyl, piperazinyl, morpholinyl or thiomorpholinyl) and that is optionally fused to a benzene ring to form a 8- to 11-membered ring system (e.g. dihydroisoquinolinyl or dihydroisoindolyl), the heterocyclic ring or ring system being optionally substituted with at least one substituent (e.g. one, two, three or four substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), hydroxyl, amido (-CONH₂), C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl), C₁-C₆, preferably C₁-C₄, alkylamino (e.g. methylamino or ethylamino), di-C₁-C₆, preferably C₁-C₄, alkylamino (e.g. dimethylamino), C₁-C₆, preferably C₁-C₄, alkyl carbonyl (e.g. methylcarbonyl or ethylcarbonyl), C₁-C₆, preferably C₁-C₄, alkyl carbonylamino (e.g. methylcarbonylamino or ethylcarbonylamino), C₁-C₆, preferably C₁-C₄, alkylaminocarbonyl (e.g. methylaminocarbonyl or ethylaminocarbonyl), di-C₁-C₆, preferably C₁-C₄, alkylaminocarbonyl (e.g. dimethylaminocarbonyl), phenyl, halophenyl (e.g. fluorophenyl or chlorophenyl), phenylcarbonyl, phenylcarbonyloxy and hydroxydiphenylmethyl.

In an embodiment of the invention, R¹¹ and/or R¹² represents a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen, oxygen and sulphur and optionally further comprising a bridging group, the ring being optionally substituted with at least one substituent (e.g. one, two or three substituents independently) selected from hydroxyl, C₁-C₆, preferably C₁-C₅, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, 1,1-dimethylpropyl or n-hexyl) and C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃).

In a further embodiment of the invention, R¹¹ and/or R¹² represents a 3- to 6-membered saturated or unsaturated ring optionally comprising at least one ring nitrogen atom and optionally further comprising a bridging group (in particular, cyclopropyl, cyclopentyl, cyclohexyl, bicyclo[2.2.1]heptyl, phenyl, pyrrolidinyl and tetrazolyl), the ring being 5 optionally substituted with at least one substituent (e.g. one, two or three substituents independently) selected from hydroxyl, C₁-C₅ alkyl and C₁-C₂ hydroxyalkyl.

In an embodiment of the invention, R¹¹ and/or R¹² represents a C₁-C₆ alkyl group 10 optionally substituted by at least one substituent (e.g. one, two, three or four substituents independently) selected from amino, hydroxyl, C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alkoxy carbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), C₁-C₆, preferably C₁-C₄, alkylcarbonylamino (e.g. methylcarbonylamino or ethylcarbonylamino) and a 3- to 6-membered saturated or 15 unsaturated ring optionally comprising at least one ring heteroatom (e.g. one, two, three or four ring heteroatoms independently) selected from nitrogen and oxygen and optionally further comprising a bridging group, the ring being optionally substituted with at least one substituent (e.g. one, two or three substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), hydroxyl, oxo, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), 20 C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃) and C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl).

In another embodiment of the invention, R¹¹ and/or R¹² represents a C₁-C₆ alkyl group 25 optionally substituted by at least one substituent (e.g. one, two, three or four substituents independently) selected from amino, hydroxyl, C₁-C₄ alkoxy, C₁-C₂ alkoxy carbonyl, C₁-C₂ alkylcarbonylamino and a 3- to 6-membered saturated or unsaturated ring optionally comprising one or two ring heteroatoms selected from nitrogen and oxygen and optionally further comprising a bridging group (in particular, cyclopropyl, bicyclo[2.2.1]heptyl, phenyl or tetrahydrofuryl), the ring being optionally substituted

with at least one substituent (e.g. one, two or three substituents independently) selected from oxo (e.g. to form a 2,5-dioxoimidazolidinyl ring) and C₁-C₂ alkyl.

In an embodiment of the invention, R¹¹ and R¹² together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen, oxygen or sulphur atom (e.g. pyrrolidinyl, piperidinyl, piperazinyl, morpholinyl or thiomorpholinyl) and that is optionally fused to a benzene ring to form a 8- to 11-membered ring system (e.g. dihydroisoquinolinyl or dihydroisoindolyl), the heterocyclic ring or ring system being optionally substituted with at least one substituent (e.g. one, two, three or four substituents independently) selected from halogen (e.g. fluorine, chlorine, bromine or iodine), hydroxyl, amido, C₁-C₆, preferably C₁-C₄, alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), C₁-C₆, preferably C₁-C₄, hydroxyalkyl (e.g. -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH or -CH(OH)CH₃), C₁-C₆, preferably C₁-C₄, alkoxy (e.g. methoxy, ethoxy, n-propoxy or n-butoxy), C₁-C₆, preferably C₁-C₄, alcoxycarbonyl (e.g. methoxycarbonyl or ethoxycarbonyl), C₁-C₆, preferably C₁-C₄, haloalkyl (e.g. trifluoromethyl), di-C₁-C₆, preferably C₁-C₄, alkylamino (e.g. dimethylamino), C₁-C₆, preferably C₁-C₄, alkylcarbonylamino (e.g. methylcarbonylamino or ethylcarbonylamino), di-C₁-C₆, preferably C₁-C₄, alkylaminocarbonyl (e.g. dimethylaminocarbonyl), phenyl, halophenyl (e.g. fluorophenyl or chlorophenyl), phenylcarbonyloxy and hydroxydiphenylmethyl.

In an embodiment of the invention, R¹¹ and R¹² together with the nitrogen atom to which they are attached form a 5- to 6-membered saturated heterocyclic ring that optionally further comprises a ring nitrogen, oxygen or sulphur atom and that is optionally fused to a benzene ring to form a 9- to 10-membered ring system, the heterocyclic ring or ring system being optionally substituted with one or two substituents independently selected from fluorine, hydroxyl, amido, C₁-C₂ alkyl, C₁-C₂ hydroxyalkyl, C₁-C₂ alkoxy, C₁-C₂ alcoxycarbonyl, C₁-C₂ haloalkyl, di-C₁-C₂ alkylamino,

C_1 - C_2 alkylcarbonylamino, di- C_1 - C_2 alkylaminocarbonyl, phenyl, chlorophenyl, phenylcarbonyloxy and hydroxydiphenylmethyl.

In another embodiment of the invention, R^{11} and R^{12} together with the nitrogen atom to which they are attached form a heterocyclic ring or ring system selected from pyrrolidinyl, piperidinyl, piperazinyl, morpholinyl, thiomorpholinyl, dihydroisoquinolinyl and dihydroisoindolyl, the heterocyclic ring or ring system being optionally substituted with one or two substituents independently selected from fluorine, hydroxyl, amido, methyl, hydroxymethyl, 2-hydroxyethyl, methoxy, methoxycarbonyl, trifluoromethyl, dimethylamino, methylcarbonylamino, dimethylaminocarbonyl, phenyl, chlorophenyl, phenylcarbonyloxy and hydroxydiphenylmethyl.

R^{12a} represents a hydrogen atom or a C_1 - C_6 , preferably C_1 - C_4 , alkyl (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl) group.

In an embodiment of the invention, R^{12a} represents a hydrogen atom or methyl group.

R^{13} represents a C_1 - C_6 , preferably C_1 - C_4 , alkyl group (e.g. methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl or n-hexyl), amino or phenyl group.

In an embodiment of the invention:

m is 1;

R^1 represents halogen;

X represents a bond, $-CH_2-$ or $-O-$, Y represents a bond, $-CH_2-$ or $-O-$ and Z represents $-CH_2-$ or $-O-$, provided that X , Y and Z are different to one another;

n is 0;

q is 1;

R^3 represents $-NHC(O)R^{10}$ or $-C(O)NR^{11}R^{12}$;

R^4 , R^5 , R^6 , R^7 and R^8 each represent hydrogen or methyl;

t is 0 or 1;

R^9 represents halogen or hydroxyl;

R^{10} represents methyl; and

R^{11} and R^{12} each independently represent hydrogen or methyl.

5 Examples of compounds of the invention include:

2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-hydroxy-N-methylbenzamide,

N-2-((2S)-3-[5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-fluorophenylacetamide,

10 2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-N-methylbenzamide,

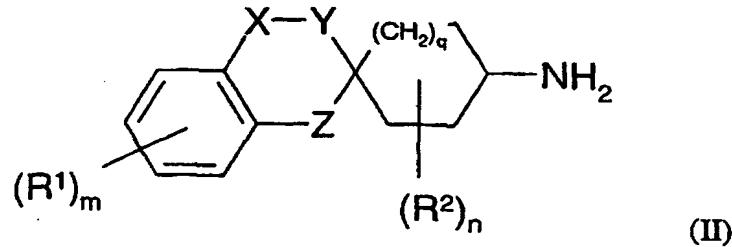
N-[2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-hydroxyphenyl]acetamide,

N-[2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxy-2-methylpropyl)oxy)-4-hydroxyphenyl]acetamide (trifluoro acetate),

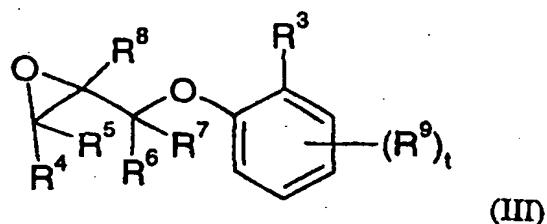
15 and pharmaceutically acceptable salts and solvates of any one thereof.

The present invention further provides a process for the preparation of a compound of formula (I) or a pharmaceutically acceptable salt or solvate thereof as defined above which comprises,

20 (a) reacting a compound of formula

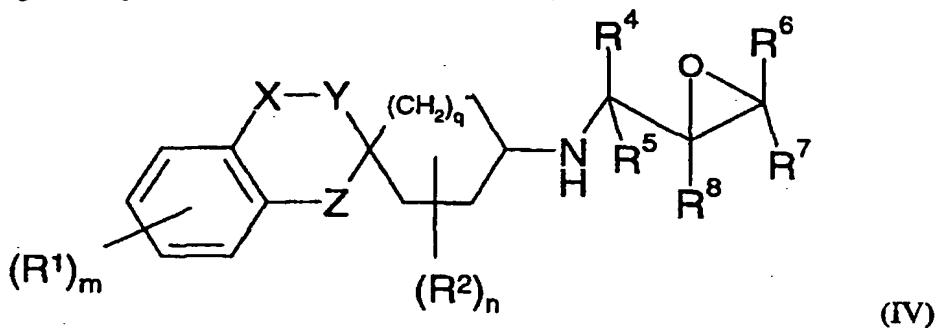


wherein m, R^1 , n, R^2 , q, X, Y and Z are as defined in formula (I), with a compound of formula

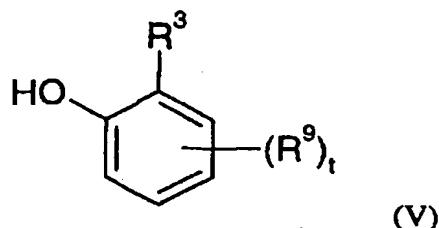


wherein R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , t and R^9 are as defined in formula (I); or

(b) reacting a compound of formula



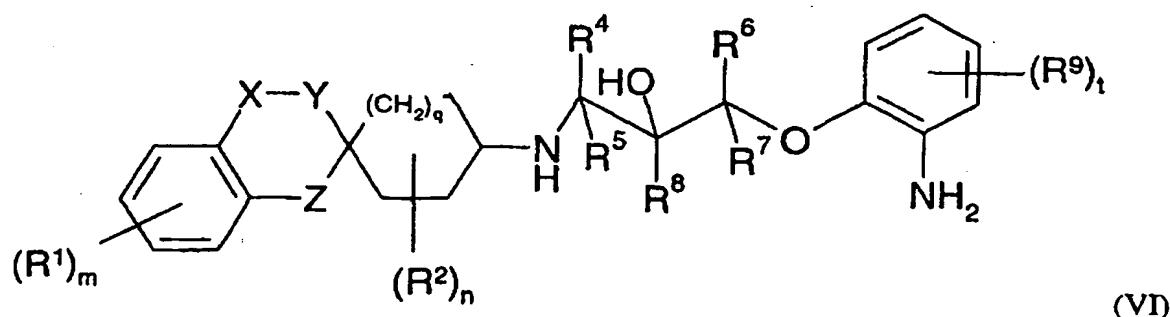
wherein m , R^1 , n , R^2 , q , X , Y , Z , R^4 , R^5 , R^6 , R^7 and R^8 are as defined in formula (I), with
a compound of formula



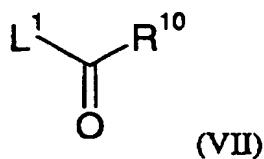
wherein R^3 , t and R^9 are as defined in formula (I), in the presence of a suitable base; or

(c) when R^3 represents $-NHC(O)R^{10}$, reacting a compound of formula

10

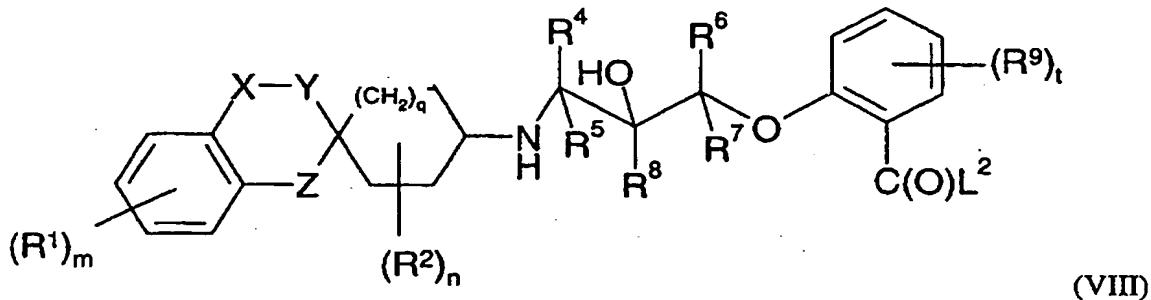


wherein m , R^1 , n , R^2 , q , X , Y , Z , R^4 , R^5 , R^6 , R^7 , R^8 , t and R^9 are as defined in formula (I),
with a compound of formula



wherein L^1 represents a leaving group (e.g. a hydroxyl group or a halogen atom such as chlorine) and R^{10} is as defined in formula (I); or

(d) when R^3 represents $-C(O)NR^{11}R^{12}$, reacting a compound of formula



wherein L^2 represents a leaving group (e.g. a hydroxyl group or a halogen atom such as chlorine) and m , R^1 , n , R^2 , q , X , Y , Z , R^4 , R^5 , R^6 , R^7 , R^8 , t and R^9 are as defined in formula (I), with a compound of formula (IX), $NHR^{11}R^{12}$, wherein R^{11} and R^{12} are as defined in formula (I); or

(e) when R^3 represents $-NHC(O)R^{10}$, R^{10} represents $-NR^{14}R^{15}$ and R^{14} and R^{15} both represent hydrogen, reacting a compound of formula (VI) as defined in (c) above with potassium cyanate;

and optionally after (a), (b), (c), (d) or (e) forming a pharmaceutically acceptable salt or solvate.

The processes of the invention may conveniently be carried out in a solvent, e.g. an organic solvent such as an alcohol (e.g. methanol or ethanol), a hydrocarbon (e.g. toluene) or tetrahydrofuran, dimethylformamide, N-methylpyrrolidinone or acetonitrile at a temperature of, for example, 0°C or above such as a temperature in the range from 0, 5, 10, 15 or 20°C to 100, 110 or 120°C.

Compounds of formulae (II), (III), (IV), (V), (VI), (VII), (VIII) and (IX) are either commercially available, are known in the literature or may be prepared using known techniques.

5 It will be appreciated by those skilled in the art that in the processes of the present invention certain functional groups such as hydroxyl or amino groups in the reagents may need to be protected by protecting groups. Thus, the preparation of the compounds of formula (I) may involve, at an appropriate stage, the removal of one or more protecting groups.

10

The protection and deprotection of functional groups is described in 'Protective Groups in Organic Chemistry', edited by J.W.F. McOmie, Plenum Press (1973) and 'Protective Groups in Organic Synthesis', 3rd edition, T.W. Greene and P.G.M. Wuts, Wiley-Interscience (1999).

15

The compounds of formula (I) above may be converted to a pharmaceutically acceptable salt or solvate thereof, preferably an acid addition salt such as a hydrochloride, hydrobromide, phosphate, acetate, fumarate, maleate, tartrate, citrate, oxalate, methanesulphonate or *p*-toluenesulphonate.

20

Compounds of formula (I) are capable of existing in stereoisomeric forms. It will be understood that the invention encompasses the use of all geometric and optical isomers (including atropisomers) of the compounds of formula (I) and mixtures thereof including racemates. The use of tautomers and mixtures thereof also form an aspect of the present 25 invention. Enantiomerically pure forms are particularly desired.

The compounds of formula (I) have activity as pharmaceuticals, in particular as modulators of chemokine receptor (especially MIP-1 α chemokine receptor) activity, and may be used in the treatment of autoimmune, inflammatory, proliferative and hyperproliferative

diseases and immunologically-mediated diseases including rejection of transplanted organs or tissues and Acquired Immunodeficiency Syndrome (AIDS).

Examples of these conditions are:

- 5 **(1) (the respiratory tract)** airways diseases including chronic obstructive pulmonary disease (COPD) such as irreversible COPD; asthma, such as bronchial, allergic, intrinsic, extrinsic and dust asthma, particularly chronic or inveterate asthma (e.g. late asthma and airways hyper-responsiveness); bronchitis; acute, allergic, atrophic rhinitis and chronic rhinitis including rhinitis caseosa, hypertrophic rhinitis, rhinitis purulenta, rhinitis sicca and rhinitis medicamentosa; membranous rhinitis including croupous, fibrinous and pseudomembranous rhinitis and scrofulous rhinitis; seasonal rhinitis including rhinitis nervosa (hay fever) and vasomotor rhinitis; sarcoidosis, farmer's lung and related diseases, fibroid lung and idiopathic interstitial pneumonia;
- 10 **(2) (bone and joints)** rheumatoid arthritis, seronegative spondyloarthropathies (including ankylosing spondylitis, psoriatic arthritis and Reiter's disease), Behcet's disease, Sjogren's syndrome and systemic sclerosis;
- 15 **(3) (skin)** psoriasis, atopical dermatitis, contact dermatitis and other eczematous dermatides, seborrhoetic dermatitis, Lichen planus, Pemphigus, bullous Pemphigus, Epidermolysis bullosa, urticaria, angiodermas, vasculitides, erythemas, cutaneous eosinophilias, uveitis, Alopecia areata and vernal conjunctivitis;
- 20 **(4) (gastrointestinal tract)** Coeliac disease, proctitis, eosinopilic gastro-enteritis, mastocytosis, Crohn's disease, ulcerative colitis, food-related allergies which have effects remote from the gut, e.g., migraine, rhinitis and eczema;
- 25 **(5) (other tissues and systemic disease)** multiple sclerosis, atherosclerosis, Acquired Immunodeficiency Syndrome (AIDS), lupus erythematosus, systemic lupus, erythematosus, Hashimoto's thyroiditis, myasthenia gravis, type I diabetes, nephrotic

syndrome, eosinophilia fascitis, hyper IgE syndrome, lepromatous leprosy, sezary syndrome and idiopathic thrombocytopenia pupura;

5 (6) (allograft rejection) acute and chronic following, for example, transplantation of kidney, heart, liver, lung, bone marrow, skin and cornea; and chronic graft versus host disease;

10 (7) cancers, especially non-small cell lung cancer (NSCLC) and squamous sarcoma;

15 (8) diseases in which angiogenesis is associated with raised chemokine levels; and

20 (9) cystic fibrosis, stroke, re-perfusion injury in the heart, brain, peripheral limbs and sepsis.

15 Thus, the present invention provides a compound of formula (I), or a pharmaceutically-acceptable salt or solvate thereof, as hereinbefore defined for use in therapy.

20 In a further aspect, the present invention provides the use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for use in therapy.

In the context of the present specification, the term "therapy" also includes "prophylaxis" unless there are specific indications to the contrary. The terms "therapeutic" and "therapeutically" should be construed accordingly.

25

The invention also provides a method of treating an inflammatory disease which comprises administering to a patient in need thereof a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined.

30

The invention still further provides a method of treating an airways disease which comprises administering to a patient in need thereof a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined.

5

For the above-mentioned therapeutic uses the dosage administered will, of course, vary with the compound employed, the mode of administration, the treatment desired and the disorder indicated. The daily dosage of the compound of formula (I) may be in the range from 0.001 mg/kg to 30 mg/kg.

10

The compounds of formula (I) and pharmaceutically acceptable salts and solvates thereof may be used on their own but will generally be administered in the form of a pharmaceutical composition in which the formula (I) compound/salt/solvate (active ingredient) is in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

15

Depending on the mode of administration, the pharmaceutical composition will preferably comprise from 0.05 to 99 %w (per cent by weight), more preferably from 0.05 to 80 %w, still more preferably from 0.10 to 70 %w, and even more preferably from 0.10 to 50 %w, of active ingredient, all percentages by weight being based on total composition.

20

The present invention also provides a pharmaceutical composition comprising a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined, in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

25

The invention further provides a process for the preparation of a pharmaceutical composition of the invention which comprises mixing a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined, with a pharmaceutically acceptable adjuvant, diluent or carrier.

30

The pharmaceutical compositions may be administered topically (e.g. to the skin or to the lung and/or airways) in the form, e.g., of creams, solutions, suspensions, heptafluoroalkane

aerosols and dry powder formulations; or systemically, e.g. by oral administration in the form of tablets, capsules, syrups, powders or granules; or by parenteral administration in the form of solutions or suspensions; or by subcutaneous administration; or by rectal administration in the form of suppositories; or transdermally.

5

The invention will now be further explained by reference to the following illustrative examples, in which ^1H NMR spectra were recorded on Varian Unity Inova 400. The central solvent peak of chloroform-d (δ_{H} 7.27 ppm), acetone-d₆ (δ_{H} 2.05 ppm), DMSO-d₆ (δ_{H} 2.50 ppm), or methanol-d₄ (δ_{H} 4.87 ppm) were used as internal standard. Low

10 resolution mass spectra and accurate mass determination were recorded on a Hewlett-Packard 1100 LC-MS system equipped with APCI /ESI ionisation chambers.

All solvents and commercial reagents were laboratory grade and used as received.

The nomenclature used for the compounds was generated with ACD/IUPAC Name Pro.

The abbreviations or terms used in the examples have the following meanings:

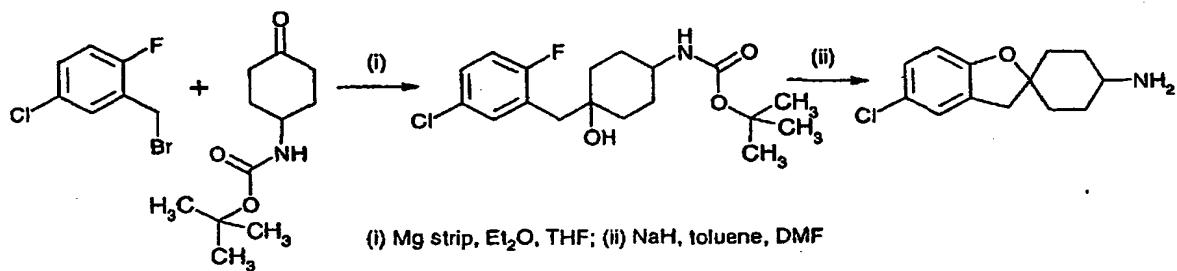
15	THF	: tetrahydrofuran
	NH ₄ Cl	: ammonium chloride
	Na ₂ SO ₄	: sodium sulphate
	NaH	: sodium hydride
	DMF	: <i>N,N</i> -dimethylformamide
20	H ₂ O	: water
	CF ₃ CO ₂ H	: trifluoroacetic acid
	K ₂ CO ₃	: potassium carbonate
	CH ₂ Cl ₂	: dichloromethane
	NH ₄ OH	: ammonium hydroxide
25	CH ₃ CN	: acetonitrile
	psi	: pounds per square inch
	Cs ₂ CO ₃	: caesium carbonate
	HCl	: hydrochloric acid
	NaHCO ₃	: sodium hydrogencarbonate
30	Et ₃ N	: triethylamine

DMAP : 4-dimethylaminopyridine

NaOEt : sodium ethoxide

Examples

5 Intermediate compound: (5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4-yl)amine



10 **Step I**

tert-Butyl[4-(5-chloro-2-fluorobenzyl)-4-hydroxycyclohexyl]carbamate

To a suspension of magnesium strip (283.6 mg, 11.67 mmol) in diethyl ether (4 mL) was added a piece of iodine followed by 0.3 mL of 2-(bromomethyl)-4-chloro-1-fluorobenzene under nitrogen atmosphere. A high intensity heat gun was applied to initiate the reaction, 15 then 2-(bromomethyl)-4-chloro-1-fluorobenzene (2.61 g, 11.67 mmol) in diethyl ether (4.5 mL) was added slowly at such a speed that a gentle reflux was maintained. After the addition was completed, the reaction mixture was refluxed for 3 hours, cooled to room temperature and a solution of *tert*-butyl (4-oxocyclohexyl)carbamate (2.49 g, 11.67 mmol) in diethyl ether (9 mL) and THF (9 mL) was added slowly with vigorous stirring. After the 20 addition was completed, the reaction mixture was left at room temperature for 3 hours.

Aqueous NH₄Cl (20 mL) was added and the mixture was stirred at room temperature overnight, extracted with ethyl acetate, washed with H₂O, dried over Na₂SO₄, filtered and concentrated in vacuo. The residue was purified by silica gel flash chromatography (0-30%ethyl acetate in petroleum benzene) to give the subtitled compound (1.4 g).

(5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amine

A mixture of *tert*-butyl[4-(5-chloro-2-fluorobenzyl)-4-hydroxycyclohexyl] carbamate (1.4 g, 3.91 mmol) and NaH (55%, 511 mg, 11.73 mmol) in toluene (21 mL) was heated at 110 °C for 5 minutes. DMF (7 mL) was added and the mixture was stirred at 110 °C for 30 minutes before allowing to cool to room temperature. The reaction mixture was partitioned between ethyl acetate and H₂O. The organic layer was dried over Na₂SO₄, filtered and concentrated. The residue was purified by HPLC (10-45% acetonitrile in H₂O, 0.1% CF₃CO₂H) to give the corresponding trifluoroacetate salt which was converted to the free base to give the titled compound (60 mg).

10

¹H-NMR (CD₃OD, 400 MHz): δ 7.15 (s, 1H), 7.06 (dd, J = 2.1, 8.5 Hz, 1H); 6.65 (d, J = 8.5, Hz, 1H); 3.27 (m, 1H); 3.11 (s, 2H); 2.15-2.05 (m, 2H); 2.00-1.91 (m, 2H); 1.90-1.80 (m, 2H); 1.75-1.56 (m, 2H).

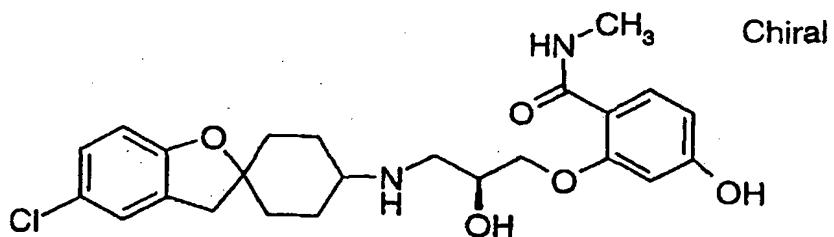
APCI-MS: m/z 238(MH⁺).

15

Example 1

2-((2*S*)-3-[(5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-4-hydroxy-N-methylbenzamide

20

**Step I****Methyl 2-hydroxy-4[(4-methoxybenzyl)oxy]benzoate**

A mixture of methyl 2,4-dihydroxybenzoate (3.36 g, 20.0 mmol), p-methoxybenzyl chloride (3.29 g, 21.0 mmol) and K₂CO₃ (2.9 g, 21.0 mmol) in acetone (40 mL) was refluxed over night, cooled to room temperature, filtered and concentrated in vacuo. The residue was dissolved in ethyl acetate and washed with H₂O. The organic layer was dried

over Na₂SO₄, filtered and concentrated. The residue was crystallized from methanol to give the sub titled compound (2.5 g).

¹H-NMR (CDCl₃, 400 MHz): δ 7.76 (d, J = 8.9 Hz, 1H); 7.39 (m, 2H); 6.94 (m, 2H); 6.55 (d, J = 2.5 Hz, 1H); 6.52 (dd, J = 2.5, 8.9 Hz, 1H); 5.00 (s, 2H); 3.99 (s, 3H); 3.84 (s, 3H).

Reference: V. Percec, D. Tomazos *J. Mater. Chem.* 1993, 3, 643-650.

Step II

2-Hydroxy-4-[(4-methoxybenzyl)oxy]-N-methylbenzamide

To a suspension of methyl 2-hydroxy-4-[(4-methoxybenzyl)oxy]benzoate (500 mg, 1.73 mmol) in methanol (15 mL) was added 40% aqueous methyl amine (3 mL) at 0 °C and the reaction mixture was stirred at room temnperature over the weekend. The volatiles were removed in vacuo to give the subtitled compound (500 mg).

¹H-NMR (DMSO-d₆, 400 MHz): δ 8.60 (m, 1H); 7.70 (d, J = 8.8 Hz, 1H); 7.38-7.33 (m, 2H); 6.96-6.91 (m, 2H); 6.49 (dd, J = 2.6, 8.8 Hz, 1H); 6.42 (d, J = 2.6 Hz, 1H); 5.00 (s, 2H); 3.75 (s, 3H); 2.77 (d, J = 4.6 Hz, 3H).

APCI-MS: m/z 288(MH⁺).

Step III

4-[(4-Methoxybenzyl)oxy]-N-methyl-2-[(2S)-oxiran-2-ylmethoxy]benzamide

A mixture of (2S)-oxiran-2-ylmethyl 3-nitrobenzenesulfonate (151 mg, 0.584 mmol), 2-hydroxy-4-[(4-methoxybenzyl)oxy]-N-methylbenzamide (168 mg, 0.584 mmol) and Cs₂CO₃ (228 mg, 0.7 mmol) in DMF (4 mL) was stirred at room temperature over night.

The reaction mixture was partitioned between ethyl acetate and H₂O. The organic layer was dried over Na₂SO₄, filtered and concentrated. The residue was purified by silica gel flash chromatography (0-90% ethyl acetate in petroleum benzene) to give the subtitled compound (150 mg).

¹H-NMR (DMSO-d₆, 400 MHz): δ 7.90 (m, 1H); 7.75 (d, J = 8.7 Hz, 1H); 7.35 (d, J = 8.6 Hz, 2H); 6.96-6.91 (m, 2H); 6.74 (d, J = 2.3 Hz, 1H); 6.69 (dd, J = 2.3, 8.7 Hz, 1H); 5.12 (s, 2H); 4.48 (dd, J = 2.5, 11.5 Hz, 1H); 4.02 (dd, J = 6.0, 11.5 Hz, 1H); 3.75 (s, 3H); 3.42 (m, 1H); 2.86 (t, J = 4.9 Hz, 1H); 2.79 (d, J = 4.7 Hz, 3H); 2.73 (dd, J = 2.7, 5.0 Hz, 1H).

s APCI-MS: m/z 344(MH⁺).

Step IV

2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-[(4-methoxybenzyl)oxy]-N-methylbenzamide

A mixture of (5-chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amine (25 mg, 0.105 mmol) and 4-[(4-methoxybenzyl)oxy]-N-methyl-2-[(2S)-oxiran-2-ylmethoxy]benzamide (36.3 mg, 0.105 mmol) in ethanol (2 mL) was stirred at 80 °C overnight. The volatiles were removed in vacuo and the residue was purified by silica gel flash chromatography (0-2% methanol in CH₂Cl₂, 0.2% NH₄OH) to give the subtitled compound (15 mg).

APCI-MS: m/z 581(MH⁺).

Step V

2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-hydroxy-N-methylbenzamide
2-((2S)-3-[(5-chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy)-4-[(4-methoxybenzyl)oxy]-N-methylbenzamide (15 mg, 0.026 mmol) was treated with 10% CF₃CO₂H in CH₂Cl₂ (3 mL) at room temperature for 20 minutes.

The volatiles were removed in vacuo and the residue was purified by HPLC (10-50% CH₃CN in H₂O, 0.2% NH₄OH) to give the titled compound (6 mg).

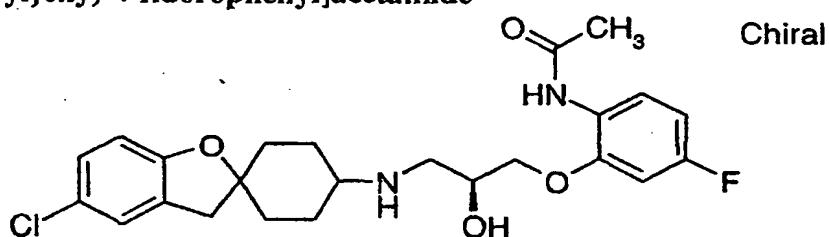
¹H-NMR (CD₃OD, 400 MHz): δ 7.79 (d, J = 8.6 Hz, 1H); 7.13 (m, 1H); 7.02 (dd, J = 2.3, 8.5 Hz, 1H); 6.61 (d, J = 8.5 Hz, 1H); 6.51 (d, J = 2.2 Hz, 1H); 6.47 (dd, J = 2.2, 8.6 Hz, 1H); 4.21-4.04 (m, 3H); 3.07 (s, 2H); 2.92 (s, 3H); 2.87 (dd, J = 4.3, 12.2 Hz, 1H); 2.77

(dd, $J = 7.5, 12.2$ Hz, 1H); 2.69 (m, 1H); 2.01 (m, 2H); 1.90 (m, 2H); 1.78 (m, 2H); 1.39 (m, 2H).

APCI-MS: m/z 461(MH $^+$).

Example 2

N-2-((2*S*)-3-[5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-4-fluorophenyl]acetamide



Step I

N-(4-Fluoro-2-hydroxyphenyl)acetamide

A mixture of 5-fluoro-2-nitrophenol (5 g, 31.8 mmol), acetic anhydride (4.86 g, 47.7 mmol) and platinum on carbon (5%, 200 mg) in methanol was hydrogenated at 35 psi for 3 hours. The catalyst was filtered off and the residue was purified by silica gel flash chromatography to give the subtitled compound (4.7 g).

15

¹H-NMR (CD₃OD, 300 MHz): δ 7.56-7.51 (m, 1H); 6.61-6.50 (m, 2H); 2.15 (s, 3H).

APCI-MS: m/z 170(MH $^+$).

Step II

20 *N*-{4-Fluoro-2-[(2*S*)-oxiran-2-ylmethoxy]phenyl}acetamide

A mixture of *N*-(4-fluoro-2-hydroxyphenyl)acetamide (1.69 g, 10.0 mmol), (2*S*)-oxiran-2-ylmethyl-3-nitrobenzenesulfonate (2.59 g, 10.0 mmol) and Cs₂CO₃ (4.87 g, 15.0 mmol) in DMF (15 mL) was stirred at room temperature for 2 hours. The reaction mixture was partitioned between ethyl acetate and H₂O. The organic layer was dried over Na₂SO₄, filtered and concentrated. The residue was purified by silica gel flash chromatography to give the subtitled compound (1.35 g).

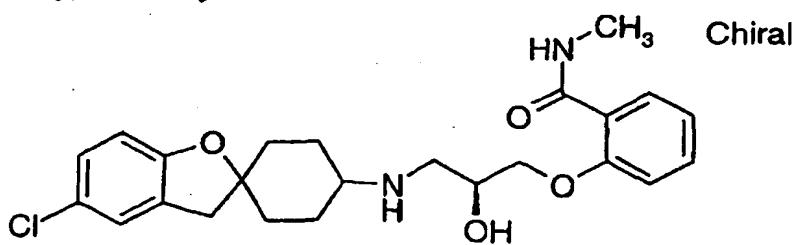
¹H-NMR (CDCl₃, 400 MHz): δ 8.33-8.29 (m, 1H); 7.71 (br. s, 1H); 6.74-6.66 (m, 2H); 4.39-4.36 (m, 1H); 3.95-3.90 (m, 1H); 3.41-3.39 (m, 1H); 2.99-2.97 (m, 1H); 2.80 (m, 1H). APCI-MS: m/z 226(MH⁺).

5

Step III**N-2-((2S)-3-[5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-4-fluorophenyl]acetamide**

A mixture of (5-chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amine (11.6 mg, 0.049 mmol) and N-{4-fluoro-2-[(2S)-oxiran-2-ylmethoxy] phenyl}acetamide (11 mg, 0.049 mmol) in ethanol (1.5 mL) was stirred at 80 °C overnight. The volatiles were removed in vacuo and the residue was purified by silica gel flash chromatography (0-1.5 % methanol in CH₂Cl₂, 0.2% NH₄OH) to give the titled compound (10 mg).

¹H-NMR (CD₃OD, 400 MHz): δ 7.87 (dd, J = 6.2, 8.9 Hz, 1H); 7.13 (m, 1H); 7.05 (dd, J = 2.3, 8.5 Hz, 1H); 6.86 (dd, J = 2.7, 10.5 Hz, 1H); 6.71-6.64 (m, 1H); 6.61 (d, J = 8.5 Hz, 1H); 4.14-4.07 (m, 2H); 3.99 (dd, J = 7.1, 10.6 Hz, 1H); 3.08 (s, 2H); 2.89 (dd, J = 4.0, 12.0 Hz, 1H); 2.77 (dd, J = 7.6, 12.0 Hz, 1H); 2.69 (m, 1H); 2.17 (s, 3H); 2.04 (m, 2H); 1.90 (m, 2H); 1.78 (m, 2H); 1.40 (m, 2H). APCI-MS: m/z 463(MH⁺).

Example 3**2-((2S)-3-[5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-N-methylbenzamide**

25

Step I

2-Hydroxy-N-methylbenzamide

A solution of methyl salicylate (5.16 mL, 40 mmol) in methanol (10 mL) was added dropwise to aqueous 40% methylamine (18.1 mL, 210 mmol) at 0 °C. After the addition was completed the reaction mixture was stirred at room temperature overnight. The volatiles were removed in vacuo to give the subtitled compound (5.48 g).

¹H-NMR (CD₃OD, 400 MHz): δ 7.70 (dd, *J* = 1.5, 7.9 Hz, 1H); 7.38-7.32 (m, 2H); 6.90-6.83 (m, 2H); 2.85 (s, 3H).

Step II***N*-Methyl-2-[(2S)-oxiran-2-ylmethoxy]benzamide**

A mixture of (2S)-oxiran-2-ylmethyl-3-nitrobenzenesulfonate (388.5 mg, 1.50 mmol), 2-hydroxy-*N*-methylbenzamide (226.5 mg, 1.50 mmol) and Cs₂CO₃ (586 mg, 1.80 mmol) in DMF (6 mL) was stirred at room temperature overnight. The reaction mixture was partitioned between ethyl acetate and H₂O. The organic layer was dried over Na₂SO₄, filtered and concentrated. The residue was purified by silica gel flash chromatography (0-50% ethyl acetate in petroleum benzene) to give the subtitled compound (284 mg).

¹H-NMR (CDCl₃, 400 MHz): δ 8.39 (m, 1H); 7.90 (br.s, 1H); 7.06-6.98 (m, 2H); 6.95-6.89 (m, 1H); 4.38 (dd, *J* = 2.5, 11.4 Hz, 1H); 3.98 (dd, *J* = 6.0, 11.4 Hz, 1H); 3.40 (m, 1H); 2.97 (t, *J* = 5.0 Hz, 1H); 2.81 (dd, *J* = 2.7, 4.8 Hz, 1H); 2.21 (s, 3H).
APCI-MS: m/z 208(MH⁺).

Step III**2-((2S)-3-[(5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-*N*-methylbenzamide**

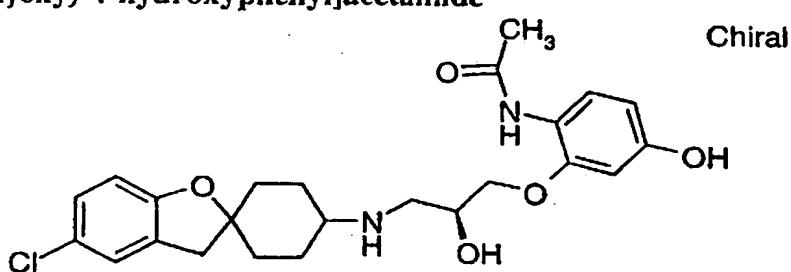
A mixture of (5-chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amine (14 mg, 0.059 mmol) and *N*-methyl-2-[(2S)-oxiran-2-ylmethoxy]benzamide (12.2 mg, 0.059 mmol) in ethanol (1.5 mL) was stirred at 80 °C over night. The volatiles were removed in

vacuo and the residue was purified by HPLC (10-50% CH₃CN in H₂O, 0.2% NH₄OH) to give the titled compound (5 mg).

¹H-NMR (CD₃OD, 400 MHz): δ 7.86 (dd, *J* = 1.7, 7.7 Hz, 1H); 7.50-7.45 (m, 1H); 7.15 (m, 2H); 7.10-7.05 (m, 1H); 7.03 (dd, *J* = 2.2, 8.5 Hz, 1H); 6.61 (d, *J* = 8.5 Hz, 1H); 4.24 (m, 1H); 4.15 (m, 2H); 3.07 (s, 2H); 2.95 (s, 3H); 2.89 (m, 1H); 2.80 (m, 1H); 2.69 (m, 1H); 2.02 (m, 2H); 1.90 (m, 2H); 1.75 (m, 2H); 1.39 (m, 2H).
APCI-MS: m/z 445(MH⁺).

10 Example 4

N-[2-((2*S*)-3-[(5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl}oxy)-4-hydroxyphenyl]acetamide



Step I

15 (1*Z*)-1-(2,4-Dihydroxyphenyl)ethanone oxime

1-(2,4-Dihydroxyphenyl)ethanone (4.5 g, 29.6 mmol) was dissolved in pyridine (17 mL). Hydroxylamine hydrochloride (2.1 g, 29.6 mmol) was added in small portions over 10 minutes. The reaction mixture was stirred at room temperature overnight. The reaction mixture was partitioned between ethyl acetate and H₂O. The organic layer was washed with H₂O, 0.2 M HCl and then concentrated. The oily residue was treated with water, evaporated to yield a white semi-solid residue which was treated with toluene and evaporated to give the subtitled compound (4.8 g) as a white solid.

APCI-MS: m/z 168(MH⁺).

Step II

2-Methyl-1,3-benzoxazol-6-ol

To a cooled (5°C) solution of (1Z)-1-(2,4-dihydroxyphenyl)ethanone oxime (9.7 g, 57.7 mmol) in acetonitrile (65 mL) and dimethylacetamide (11 mL) was added phosphorous oxychloride (5.6 mL, 60.3 mmol) dropwise. The temperature was not allowed to exceed 10°C during the addition. After 1 hour stirring at room temperature the yellow slurry was poured into a mixture of aqueous NaHCO_3 and ice. The resulting precipitate was filtered off and dried to give the subtitled compound (6.3 g).

$^1\text{H-NMR}$ (DMSO- d_6 , 400 MHz): δ 7.40 (d, 1H); 6.98 (s, 1H); 6.89 (d, 1H); 2.45 (s, 3H).
APCI-MS: m/z 150(MH^+).

Step III**2-Methyl-1,3-benzoxazol-6-yl acetate**

A slurry of methyl-1,3-benzoxazol-6-ol (7.1 g, 47.8 mmol) in THF 150 mL was cooled to 10°C and Et_3N (5.8 mL, 81.3 mmol) was added in one portion, followed by the addition of acetyl chloride (11.3 mL, 81.6 mmol) in small portions. After addition was completed the reaction mixture was stirred at room temperature overnight. The reaction mixture was partitioned between ethyl acetate and water. The organic layer was dried over Na_2SO_4 , filtered and concentrated to give the subtitled compound (8.2 g).

$^1\text{H-NMR}$ (DMSO- d_6 , 400 MHz): δ 7.65 (d, 1H); 7.47 (s, 1H); 7.15 (d, 1H); 2.60 (s, 3H); 2.24 (s, 3H).

Step IV**4-(Acetylamino)-3-hydroxyphenyl acetate**

To a solution of 2-methyl-1,3-benzoxazol-6-yl acetate (5.05 g, 28.8 mmol) in THF (100 mL) a mixture trifluoroacetic acid/water (4 ml/10 mL) was added. The reaction mixture was stirred at room temperature for 16 hours, then saturated aqueous NaHCO_3 (150 mL) was added. The mixture was extracted with ethyl acetate (150 mL), dried over Na_2SO_4 , filtered and concentrated in vacuo to give the subtitled compound (4.0 g)

Step V**4-(Acetylamino)-3-[(2S)-oxiran-2-ylmethoxy]phenyl acetate**

A solution of 4-(acetylamino)-3-hydroxyphenyl acetate (669 mg, 3.2 mmol), (2S)-oxiran-2-ylmethyl-3-nitrobenzenesulfonate (748 mg, 2.9 mmol) and Cs₂CO₃ (1.05 g, 3.2 mmol) in 1-methyl-pyrrolidinone (10 mL) was stirred at room temperature overnight. The reaction mixture was partitioned between ethyl acetate and water. The organic layer was dried over Na₂SO₄, filtered and concentrated to give a yellow oil which was suspended in methanol/diethyl ether. The precipitate was filtered off and dried to give the subtitled compound (296 mg).

¹H-NMR (CDCl₃, 400 MHz): δ 8.40 (d, 1H); 7.80 (s, 1H); 6.78 (m, 2H); 4.39 (m, 1H); 3.92 (m, 1H); 3.40 (m, 1H); 2.98 (t, 1H); 2.80 (m, 1H); 2.25 (s, 3H); 2.20 (s, 3H).

Step VI**N-[2-((2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxypropyl)oxy]-4-hydroxyphenyl]acetamide**

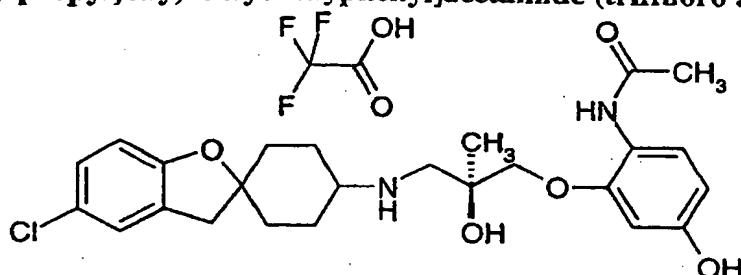
A mixture of (5-chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amine (14 mg, 0.06 mmol) and 4-(acetylamino)-3-[(2S)-oxiran-2-ylmethoxy]phenyl acetate (16 mg, 0.06 mmol) in ethanol (1.5 mL) was stirred at 80 °C over the weekend. The volatiles were removed in vacuo and the residue was purified by silica gel flash chromatography (0-3.5% methanol in CH₂Cl₂, 0.2% NH₄OH) to give the titled compound (15 mg).

¹H-NMR (CD₃OD, 400 MHz): δ 7.53 (d, J = 8.6 Hz, 1H); 7.13 (m, 1H); 7.03 (dd, J = 2.3, 8.5 Hz, 1H); 6.61 (d, J = 8.5 Hz, 1H); 6.47 (d, J = 2.5 Hz, 1H); 6.36 (dd, J = 2.5, 8.6 Hz, 1H); 4.11-4.04 (m, 1H); 4.02 (dd, J = 4.0, 9.8 Hz, 1H); 3.95 (dd, J = 6.0, 9.8 Hz, 1H); 3.08 (s, 2H); 2.89 (dd, J = 4.2, 12.2 Hz, 1H); 2.75 (dd, J = 8.1, 12.2 Hz, 1H); 2.68 (m, 1H); 2.11 (s, 3H); 2.02 (m, 2H); 1.90 (m, 2H); 1.78 (m, 2H); 1.39 (m, 2H).

APCI-MS: m/z 461(MH⁺).

Example 5

N-[2-((2*S*)-3-[(5-Chloro-3*H*-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxy-2-methylpropyl]oxy)-4-hydroxyphenyl]acetamide (trifluoro acetate)

**Step I****2-Methyl-1,3-benzoxazol-6-yl benzoate:**

To a stirred suspension of 2-methyl-1,3-benzoxazol-6-ol (2.99 g, 20 mmol) in dichloromethane (50 mL) was added triethylamine (4.05 g, 5.58 mL, 40 mmol). A solution of benzoyl chloride (3.09 g, 2.56 mL, 22 mmol) in dichloromethane (20 mL) was added dropwise over about 10 minutes. The reaction mixture was stirred at room temperature for 2.5 hours, then washed with water (2 x 50 mL), and dried over Na₂SO₄, filtered and concentrated in vacuo to give the subtitled compound as colourless solid (5.05 g, 20 mmol, quant.).

15 ¹H-NMR (400 MHz, CDCl₃): δ 8.22 (m, 2H), 7.66 (m, 2H), 7.53 (m, 2H), 7.40 (d, 1H), 7.16 (dd, 1H), 2.65 (s, 3H).

APCI-MS: m/z 254 [MH⁺].

Step II**4-(Acetylamino)-3-hydroxyphenyl benzoate:**

To a solution of 2-methyl-1,3-benzoxazol-6-yl benzoate (5.05 g, 20 mmol) in THF (100 mL) a mixture trifluoroacetic acid/water (4 ml/10 mL) was added. The reaction mixture was stirred at room temperature for 16 hours, then saturated aqueous NaHCO₃ (150 mL) was added. The mixture was extracted with ethyl acetate (150 mL), dried over Na₂SO₄, filtered and concentrated in vacuo to give the subtitled compound.

¹H-NMR (400 MHz, acetone-d₆): δ 9.76 (br.s, 1H), 9.32 (br.s, 1H), 8.15 (m, 2H), 7.71 (m, 1H), 7.60 (m, 2H), 7.47 (d, 1H), 6.85 (m, 1H), 6.75 (m, 1H), 2.20 (s, 3H).
APCI-MS: m/z 272 [MH⁺].

5 **Step III**

[(2S)-2-Methyloxiranyl]methyl3-nitrobenzenesulfonate

To an oven-dried 1000 mL three-necked flask was added powdered activated molecular sieves (8.0 g, 4 Å) and CH₂Cl₂ (440 mL), D-(−)-diisopropyl tartrate (4 mL, 14.2 mmol) and 2-methyl-2-propene-1-ol (20 mL, 240 mmol) was added and the mixture was cooled to −20 °C. Titanium tetrakisopropoxide (3.5 mL, 11.9 mmol) was added with a few millilitres of CH₂Cl₂ and the mixture was stirred at −20 °C for 30 minutes. Cumene hydroperoxide (75 mL, 430 mmol) was added dropwise over 1.5 hours maintaining the temperature at −20 °C. The mixture was stirred at this temperature overnight. Trimethyl phosphite (40 mL, 340 mmol) was added dropwise over 5 hours maintaining the temperature at −20 °C. Triethylamine (50 mL, 360 mmol) and DMAP (3.48 g, 28.5 mmol) was added followed by a solution of 3-nitrobenzenesulphonyl chloride (47 g, 212 mmol) in CH₂Cl₂ (400 mL). The temperature was raised to −10 °C and the mixture was stirred at this temperature overnight. After removing the external cooling vessel, the reaction mixture was filtered through celite. The organic phase was washed with 10% tartaric acid (500 mL), saturated NaHCO₃ (300 mL) and brine (300 mL). The organic layer was dried over MgSO₄ and concentrated in vacuo to give 150 g of a yellow oil. The crude material was purified by silica gel flash chromatography (0-50% ethyl acetate in heptane) to give the subtitled compound (48.8 g).

¹H-NMR (CDCl₃, 400 MHz): δ 8.79-8.75 (m, 1H); 8.52 (ddd, J = 1.1, 2.3, 8.3 Hz, 1H); 25 8.25 (ddd, J = 1.1, 1.8, 7.8 Hz, 1H); 7.81 (t, J = 8.5 Hz, 1H); 4.28 (d, J = 11.3 Hz, 1H); 4.05 (d, J = 11.3 Hz, 1H); 2.73 (d, J = 4.4 Hz, 1H); 2.67 (d, J = 4.4 Hz, 1H); 1.56 (s, 3H).

Step IV:

4-(Acetylamino)-3-{{(2S)-2-methyloxiran-2-yl)methoxy}phenyl benzoate}

A mixture of 4-(acetylamino)-3-hydroxyphenyl benzoate (2.71 g, 10 mmol), [(2S)-2-methyloxiran-2-yl]methyl3-nitrobenzenesulfonate (2.73 g, 10 mmol) and Cs₂CO₃ (3.57 g, 11 mmol) in 1-methylpyrrolidin-2-one (35 mL) was stirred at room temperature overnight. The reaction mixture was partitioned between ethyl acetate and water. The organic layer was dried over Na₂SO₄, filtered and concentrated. The residue was purified by silica gel flash chromatography (ethyl acetate/n-heptane) to give the sub titled compound as a colourless solid (1.31g, 3.9 mmol, 39 %).

¹H-NMR (400 MHz, CDCl₃): δ 8.41 (d, 1H), 8.18 (m, 2H), 7.91 (br.s, 1H), 7.63 (m, 1H), 7.50 (m, 2H), 6.83 (m, 1H), 4.15 (d, J = 10.8 Hz, 1H), 4.03 (d, J = 10.8 Hz, 1H), 3.99 (d, J = 10.8 Hz, 1H), 2.92 (d, J = 4.6 Hz, 1H), 2.78 (d, J = 4.6 Hz, 1H), 2.22 (s, 3H), 1.48 (s, 3H).

APCI-MS: m/z 342 [MH⁺].

15 Step V

N-[2-({(2S)-3-[(5-Chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-yl)amino]-2-hydroxy-2-methylpropyl}oxy)-4-hydroxyphenyl]acetamide (trifluoro acetate)

A mixture of 5-chloro-3H-spiro[1-benzofuran-2,1'-cyclohexan]-4'-amine (20 mg, 0.084 mmol) and 4-(acetylamino)-3-[(2S)-2-methyloxiran-2-yl]methoxy phenyl benzoate (29 mg, 0.084 mmol) in ethanol (1.5 mL) was stirred at 80 °C over night, 2 drops conc NaOEt was added and the mixture was stirred at room temperature for 4 hours. The volatiles were removed in vacuo and the residue was purified by HPLC (10-80 % acetonitrile in water, 0.1% CF₃CO₂H) to give the titled compound (20 mg).

25 ¹H-NMR (400 MHz, CD₃OD): δ 7.19-7.13 (m, 2H); 7.08-7.03 (m, 1H); 6.67-6.62 (m, 1H); 6.50 (m, 1H); 6.43-6.39 (m, 1H); 3.90 (m, 2H); 3.38-3.00 (m, 5H); 2.20 (m, 2H); 2.23 (s, 3H); 2.22-1.90 (m, 2H); 1.82 (m, 2H); 1.68 (m, 2H); 1.42 (s, 3H).

APCI-MS: m/z 475 [MH⁺].

THP-1 Chemotaxis Assay

Introduction

The assay measures the chemotactic response elicited by MIP-1 α chemokine in the human monocytes cell line THP-1. Compounds are evaluated by their ability to depress the chemotactic response to a standard concentration of MIP-1 α chemokine.

Methods

Culture of THP-1 cells

- 10 Cells are thawed rapidly at 37°C from frozen aliquots and resuspended in a 25 cm flask containing 5 ml of RPMI-1640 medium supplemented with Glutamax and 10% heat inactivated fetal calf serum without antibiotics (RPMI+10%HIFCS). At day 3 the medium is discarded and replaced with fresh medium.
- 15 THP-1 cells are routinely cultured in RPMI-1640 medium supplemented with 10% heat inactivated fetal calf serum and glutamax but without antibiotics. Optimal growth of the cells requires that they are passaged every 3 days and that the minimum subculture density is 4×10^5 cells/ml.

Chemotaxis assay

- Cells are removed from the flask and washed by centrifugation in RPMI + 10%HIFCS + glutamax. The cells are then resuspended at 2×10^7 cells/ml in fresh medium (RPMI + 10%HIFCS + glutamax) to which is added calcein-AM (5 μ l of stock solution to 1 ml to give a final concentration of 5×10^{-6} M). After gentle mixing the cells are incubated at 37°C in a CO₂ incubator for 30 minutes. The cells are then diluted to 50 ml with medium and washed twice by centrifugation at 400xg. Labelled cells are then resuspended at a cell concentration of 1×10^7 cells/ml and incubated with an equal volume of MIP-1 α antagonist (10^{-10} M to 10^{-6} M final concentration) for 30 minutes at 37°C in a humidified CO₂ incubator.

Chemotaxis is performed using Neuroprobe 96-well chemotaxis plates employing 8 µm filters (cat no. 101-8). Thirty microlitres of chemoattractant supplemented with various concentrations of antagonists or vehicle are added to the lower wells of the plate in triplicate. The filter is then carefully positioned on top and then 25µl of cells preincubated with the corresponding concentration of antagonist or vehicle is added to the surface of the filter. The plate is then incubated for 2 hours at 37°C in a humidified CO₂ incubator. The cells remaining on the surface are then removed by adsorption and the whole plate is centrifuged at 2000 rpm for 10 minutes. The filter is then removed and the cells that have migrated to the lower wells are quantified by the fluorescence of cell associated calcein-AM. Cell migration is then expressed in fluorescence units after subtraction of the reagent blank and values are standardized to % migration by comparing the fluorescence values with that of a known number of labelled cells. The effect of antagonists is calculated as % inhibition when the number of migrated cells is compared with vehicle.